The LESS Accord: Low Energy Sustainable Streaming

Formerly 'Greening of Streaming: Gold Button'

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Abstract

Greening of Streaming is an industry body that comprises many of the most significant operators, service providers, and technology vendors in the streaming industry. It acts to improve energy efficiency and sustainability efforts relating to streaming services architecture and design, promoting power as an equally important design consideration to price and performance in system development.

With significant international traction and many active working groups spanning all aspects of the streaming workflow, Greening of Streaming is practical and pioneering. It is not an accreditation or offsetting group: It is focussed on real world engineering improvements to streaming systems. Neither is it a standards development organization (SDO). It is a user group (UG) that seeks to work with SDOs to encourage consideration of energy efficiency as a 'first class' key performance indicator (KPI) in the development of technical standards that relate to streaming.

The Low Energy Sustainable Streaming (LESS) Accord is a movement that Greening of Streaming is driving across the industry, inviting participation from diverse stakeholders in the development of streaming. The LESS Accord aims to dig deep into the heart of the broadcast and streaming industry and ask a taboo question of an historically quality-obsessed industry :

"What if the default streaming encoding profile was energy optimized with 'acceptable' quality for general viewing rather than, as it is today, quality optimized (and typically overprovisioned) with no energy consideration?"

The fundamental idea is that, in many cases, consumers cannot tell the difference between various streaming and broadcast service qualities, and increasingly the industry relies on computer-aided techniques to differentiate quality that humans cannot perceive.

One motivation behind the LESS Accord is to "give permission" to stakeholders to ask out loud what many engineers in the industry already instinctively, privately think and to explore how we might be able to deliver services that fulfill consumer's expectations without simply overselling imperceptible quality/value propositions and creating inappropriate, expensive, unsustainable, and unnecessary energy demands for no benefit to the viewer.

These energy demands may have environmental and economic impacts. The LESS Accord seeks to reduce those impacts.

CCS Concepts:

•Computer systems organization~Architectures~Distributed architectures~Cloud computing•Networks~Network performance evaluation~Network measurement•Networks~Network services~Cloud computing

Additional Keywords and Phrases:

streaming, energy efficiency, content delivery networking, encoding, video compression

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1 Introduction

In the last decades, streaming has evolved from a niche application into a mainstream consumer activity and has become a key driver of the growth of distributed computing and network services. Estimates vary, but indications are that the vast majority of Internet traffic today is video streaming data.

Streaming service architecture has developed with a proposition of quality as its foremost objective. Economic success relies on providing a consumer experience with like-for-like (at least) quality to competing traditional broadcast network services such as digital terrestrial television (over-the-air [OTA]) or cable/satellite (direct-to-home).

Streaming services, unlike other broadcasting services, use the Internet, and the Internet is a resource shared with many other applications. This sharing, along with derived economies of scale, means that from the outset streaming is defensibly more sustainable than building new private networks to reach audiences. For this reason, many of the traditional broadcast networks are struggling to compete with streaming services, both economically and in accounting for their sustainability and environmental impact.

Quality differentiation has for the past two decades been the most notable competitive advantage that traditional broadcast networks have maintained over streaming services. However, as the quality of streaming services has increasingly met consumer expectations, or as additional functionality that streaming services bring (such as on-demand viewing, pause and rewind of live programming, etc.) adoption has accelerated and in some models surpassed traditional broadcast consumption.

In the "best effort" delivery model of TCP/IP and the compute architectures that underpin the Internet and streaming applications, overprovisioning of service availability has been the natural way to meet quality expectations. Content delivery networks (CDNs) are provisioned with vast arrays of distributed computing, enabled as caches or stream-splitters. Cloud computing architectures deploy redundancy through provisioning of a plurality of servers. Typically service architectures employ 1+1 (a doubling of systems) or at the very least n+1 (hot spare systems) to ensure that if a component in the systems fails then a backup can be brought into play efficiently and service continuity can be maintained.

As video production quality has improved and screen resolutions have increased, so too have the distributed qualities of encoded/compressed video. The market has for years competed on key performance indicators such as latency, bitrate, network and compute price and performance, numbers of pixels, color depths, and more.

Today the combination of overprovisioning, video quality, network speeds, and economies of scale mean that for many consumers the services they use far exceed what is sufficient to deliver an engaging and, for all intents and purposes, flawless service the great majority of the time.

However, the pursuit of quality optimization continues, sucking up intellectual, technical, and economic focus and creating the entire framework for the industry's competitive landscape. Arguments for and against the benefits of latency drive technologies such as edge computing or CDN switching. Arguments for and against the benefits of compression drive the availability of 8K and 16K video.

Yet only a tiny fraction of consumers can discern and appreciate these differences, and most would need machines to determine which of these quality drivers is theoretically bringing them value.

So in short, the streaming industry is now "good enough" for the vast majority of users, and continued efforts to deliver increased quality are bringing little real value to viewers.

While beyond the scope of the LESS Accord, rolling out new streaming technologies such as set-top boxes or new codec DSPs in mobile phones can cause perfectly effective, and often underutilized, technologies to become prematurely obsolete. This is of concern to those who are focussed on sustainability, since the embedded emissions, pollution, and use of manufacturing resources embodied in those new devices may be relatively indefensible. While in Greening of Streaming we are dominantly (although not

exclusively) focussed on operational energy efficiency, we recognise that there are interdependencies with a wider systemic range of impacts of which we must constantly be mindful. For the moment, we are playing to our expertise and strengths, but remain open to challenges to our proposed strategies that may arise from unintended consequences in the wider ecosystem.

With that said, returning to focus on the LESS Accord, the operational energy required for service delivery is growing significantly. While figures and estimates vary wildly, estimates are that the combination of fixed and mobile telecommunications, broadcast services, and consumer electronics consume 3% to 5% of the electricity produced for many countries. Regardless of the actual number, energy costs are increasing and so the cost of providing streaming services is also increasing. This is not just a cost to the industry, but this cost is measurable for the consumer too.

In the author's own home testing, a 70-inch TCL TV consumes 75W displaying the electronic programming guide (EPG) and 85W displaying OTA broadcast or standard-definition (SD) YouTube streaming, but then jumps to a significantly higher 135W when displaying high dynamic range (HDR) streaming. While conjectural, it is assumed that this increased energy consumption may be due to software central processing unit (CPU) decoding of the content. Whatever the cause of the increase, it is not an increase that most consumers will be aware of. One hour of HDR adds 0.05 kWH to the consumer's energy bill, and at 34.1p /kWh that would be around 2p an hour. That may or may not be "worth it" as a value proposition to the consumer, but at the time of writing no information anywhere makes it clear to the consumer that this is a hidden cost of opting into HDR, regardless of the environmental impact.

While a 50W increase may not seem like a lot (merely the wattage of an old tungsten lightbulb), extrapolating that increase out in the context of a sports bar with 7 similar screens (such as one familiar to the author), opting to display 12 hours a day of HDR will add £515 per year (0.05 *12h *30d *12m *0.341p *7) to that venue's energy bill. While this may or may not be consequential to the sports bar's business (an entirely different topic), it is nonetheless important to recognise that a technical decision made by the streaming industry has a notable financial impact on the consumer regardless of the environmental impact.

2 Solutions that have been explored

First and foremost, it can be argued that consumers have options today. Most TV sets have an "eco mode" that has been included for compliance with various consumer electronic standards, certification, and more.

While streaming services typically default to an 'auto' mode that displays the highest quality stream available to the end user's device using techniques such as adaptive bitrate (ABR), most offer consumers the option to override that automatic rate selection and select the rate that they wish to consume. Bitrate itself may or may not affect energy consumption (and a large amount of work is being undertaken by Greening of Streaming on this subject, particularly in the context of live streaming at scale in Working Group 4, where early indications contrast with much of the anecdotally formed science of "data attribution" that has, seemingly erroneously, assumed that there is correlation between data transfer volumes and network distribution energy). However, bitrate is typically a good indicator of underlying video quality, and higher bitrates typically indicate compression of video formats such as HDR, ultra-high definition (UHD), 4K, 8K, and so on. As outlined above, these can and do have effects on the energy required for compression and decompression of the video. So where a user opts into a lower bitrate they may well also reduce the decompression energy required.

It is these adjustments that have been associated with "Green Button" experiments, where consumers seeking to stream in a socially/environmentally responsible way have been provided an option to reduce bitrates, thus typically reducing decoding / decompression energy demands and so defensibly promoting the capability as a "green alternative."

The problem is that consumers do not typically buy a 4K, HDR-capable TV, with a 1Gbps internet connection and then opt in to cripple that quality. Surveys carried out in 2022 by YouGov on behalf of Greening of Streaming to more than 2,000 randomly selected members of the public indicated that an unmeasurable fraction of that sample actually opted into an "eco mode" service of any type (basically a zero result). In fact the wider conclusion of that survey was that a) there was little awareness of the relationship between consumption of streaming, its modes, and the related

variance in energy demand, and b) consumers strongly believe it is the technically aware and informed industry that needs to make such decisions for them..

This problem is absolutely the industry's problem to solve, and the consumer is simply a passenger riding on those decisions.

3 The Good Enough service with the Gold Button option

At the IBC Conference in 2022, various members of the Greening of Streaming community discussed the formation of the long anticipated Working Group 6, focussed on compression and decompression. In the context of the issues laid out in section 1, one of the conversations discussed the idea that there might be value in exploring "some kind of flag" in the ABR bitrate ladder system that marked a particular rung of the available bitrates as being optimized for energy efficiency. Further, the discussion asked if the default streaming mode targets this rung, could that rung (and that rung alone) be pre-positioned in cache in the CDN, and could that rung target just a single ubiquitous codec, such as H.264.

If such a default streaming bitrate was deployed would the consumer know, or indeed care in most cases? Was there an encoding quality that could be considered "good enough" for the vast majority of viewing situations? If there was, could all other bitrates be removed from pre-positioning strategies in the CDNs, and potentially could the amount of effort in transcoding the ABR ladders be simplified? And could, therefore, the scaling of the CDN cache demand, the compute requirements to encode, and more importantly the diversity of digital signal processors (DSPs) and CPU options to decode that content be simplified—and potentially the energy demand reduced?

While such a model contrasts strongly to the design principles of chasing the highest quality that broadcast and streaming have fostered for many decades, it was also critically noted that defaulting to "good enough" streaming quality would not exclude or preclude consumers being offered options to upgrade the content to higher bitrate (HDR/4K/8K/UHD etc) experiences. The only suggested limiting factor—one that inverted the already tried and failed "eco-mode" or "Green Button" models—was that "Gold Button" interactions would only raise the quality on a program-by-program basis. If the consumer could permanently choose the higher bitrate version, then of course he or she would be inclined to consume more energy once, and then forget.

Here's a useful analogy: We boil a kettle when we want a coffee, but we don't install a boiling water tap to provide 24/7 instant-on coffee. The key idea is that the interaction itself makes the consumer aware that they are committing to the increased energy consumption, related costs, and environmental impacts.

4 The challenges

Obviously one of the biggest challenges of this suggestion (and to be honest its most exciting aspect) is that it completely disrupts the status quo of an industry founded on the pursuit of the best quality at all times. The foundation of sales and marketing of broadcast and streaming technology is built on faster network connections, more Gs, higher resolutions, wider screens, and so on. To try to change that proposition is much bigger even than the metaphorical "changing the direction of an oil tanker".

However, the current combination of climate concern and increasing energy costs provides the fuel for such a complex discussion to engage the intellectual power of the industry.

On top of this is another key consideration: Technological advancement has been hitting a ceiling recently. Innovation in compression has slowed significantly. Whereas the step changes between MPEG-2 and MPEG-4 compression were considerable, the step changes between H.264 and H.265 have been far less notable, and more recently the AV1 compression and VVC compression improvements (while valuable in some specific contexts) have required many many times the effort, with relatively small incremental improvements compared to the earlier innovations.

It is important to note that simply refocusing the intellectual capital to invest in using the same bitrates but with increased energy efficiency opens the scope for considerably more innovation than chasing ever-higher quality with ever-lower bitrate. For the industry, this

path opens the door for wider collaborations, invites a new generation to innovate in a meaningful way, and has the potential for significant benefits and outcomes for the industry and for the consumer.

The final challenge that Working Group 6 (compression and decompression) has acknowledged is that it cannot dictate anything to the industry. The best way to change the industry is to make it want to change itself—to find an accord where the industry itself leads reform from the core. To do this, the seeds of this discussion must be spread to the industry, and permission to question the quality paradigm must be granted to engineers across the industry to see if they engage.

The near-universal positive response to the proposition so far indicates that this is a topic that is not only surprisingly ripe for discussion, but actually exciting for many industry stakeholders.

5 Formalization

This conversation has come out of Working Group 6, expanded at numerous industry meetings, has found support among key groups like DPP, IABM, IBC, and more, and has matured into Greening of Streaming's formally named Low Energy Sustainable Streaming (LESS) Accord.

This paper, and various other blog posts and presentations that are now being generated by members of Greening of Streaming, seek to engage the industry, invite input, and explore the possibilities for an energy-efficient default model.

Greening of Streaming members hope to identify the best ideas by summer 2023 and define real-world production testing models by autumn 2023. We will present these testing models at IBC in September 2023 and then run the tests through Q4 2023 and Q1 2024, working through Q2 2024 to produce outcomes and a proposed accord at the end of that cycle.

It is not intended that the accord be a standard. The industry would be unlikely to accept a standard of this scale being defined so loosely so quickly, and it is not Greening of Streaming's role to try to define standards. Instead, the LESS Accord is at best a reference for the industry to align around in order to begin to travel in a common direction. In turn, expert SDOs (standards development organizations) can work to produce standards that are practicable in their specific domains, but with the knowledge that the rest of the industry is also working toward common goals, refocused on energy efficiency as a key performance indicator rather than as an afterthought.

Acknowledgements

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Thanks to all Greening of Streaming members for their incredible motivation and thought leadership as we raise complex issues across our industry. Thanks specifically to Sam Orton-Jay, Working Group 6 lead, for keeping things focussed and adding a degree of discipline to the practical work in evolving the LESS Accord. Thanks to Adrian Roe, Steve Strong, and Eric Schumacher-Rasmussen at id3as for providing the latitude, resources, and farsighted support to create Greening of Streaming in the first place, and for keeping the whole thing on rails. Thanks to all the volunteer secretariat for everything they do across the organization.

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References

We encourage readers to explore the Greening of Streaming blog which can be found at www.GreeningofStreaming.org/blog